12/28/07 UPDATE

LABORATORY-BASED PHYSICAL SCIENCE CURRICULUM

The goal of this curriculum is to increase the number of students meeting state science standards at the high school level. This can be done through this course of study in physical science, which is aligned with state science standards and meets the entrance requirements of post-secondary institutions.

Numbers in parentheses reference the Nebraska Twelfth-Grade Science Standards.

Table of Contents

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SECTION I **INTRODUCTION TO SCIENCE**

Concepts and Skills	Suggested Activities and Resources	Suggested Assessments

Introduction to Science (5 days & 1 day per week throughout the rest of the course)

12.2.1 Scientific Inquiry

a. Formulate questions and identify concepts that guide scientific investigations.
b. Design and conduct scientific investigations.
c. Use technology and mathematics to improve investigations and communications.
d. Formulate and revise scientific explanations and models using logic and evidence.
e. Recognize and analyze alternative explanations and models.
f. Communicate and defend a scientific argument.

A. Features of Inquiry:

1. Engaging in Scientifically Oriented Questions
   a. Questioning
   b. Predicting
   c. Forming Hypotheses

2. Responding to Questions using Evidence
   a. Identifying Variables
   b. Designing Experiments
      i. Understand that larger well-chosen samples produce more accurate estimates of the characteristics of the total population. (12.1.2)
   c. Making Qualitative and Quantitative Observations
      i. Understand that measurement errors may affect results of calculations. (12.1.3)
   d. Recording Data

3. Formulating Explanations from Evidence
   a. Organizing Data
      i. Understand that the way data are displayed affects interpretation. (12.1.2)
         1) Graphs
         2) Tables
         3) Calculations
      ii. Uses of powers of ten to represent large and small numbers. (12.1.3)
         1) Schematics
   b. Manipulating Data
   c. Interpreting Evidence
      i. Evaluate the reasonableness of answers to problems. (12.1.2)
      ii. Understand that a correlation between two variables does not mean that either one causes the other. (12.1.2)
      iii. Compare data for two groups by using averages and ranges of values. (12.1.3)
      iv. Describe rate of change by comparing one measured quantity to another measured quantity. (12.1.3)
      v. Investigate and describe how different characteristics, properties, or relationships within a system change as their dimensions increase or decrease. (12.1.3)
   d. Creating Models
      i. Create a physical, mental, or mathematical model to show how objects and processes are connected (12.1.2)

Concepts and Skills	Suggested Activities and Resources	Suggested Assessments
4. Connecting Explanations to Scientific Knowledge a. Inferring b. Connecting to Existing Models i. Test the usefulness of the model by comparing its predictions to actual observations. (12.1.2) c. Defending Findings i. Evaluate the reasonableness of answers to problems. (12.1.2) 5. Communicating and Justifying Explanations a. Communicating Explanations b. Defending Explanations c. Publishing d. Determining Applications e. Asking Further Questions		
	• Logical arguments • Science versus what is not scientific (belief based) • Sample size and validity • Communicate results in a scientific format 1. A step in time Construct a Pendulum that has a period of one second. This culminates in a class competition. 2. Egg Bungee Jump This application of Hooke's Law allows students to collect, graph and interpret data. Students culminate this activity by bungee jumping a raw egg as close to the floor without hitting the floor.	Directed Project • Discuss examples of final projects. • Discuss possible topics • Formulate a project proposal • Establish a timeline for components completion. • Complete sample inquiry projects as a class. • Keep a journal of project progress.
6. 12.1.3 Change, constancy, and measurement a. Uses of powers of 10 (Atoms –> the universe) b. Compare data i. Measurement errors and results c. Rate of change by comparing one measured quantity to another measured quantity i. Scientific notation		
7. 12.1.2 Evidence, models, and explanation a. Understand that the way data are displayed affects interpretation. b. Evaluate the reasonableness of answers to problems. c. Sample Activity: Collect data, such as mass vs. volume of different substances. i. Create a physical, mental, or mathematical model to show how objects and processes are connected. ii. Test the usefulness of the model by comparing its predictions to actual observations. iii. Understand that a correlation between two variables does not mean that either one causes the other.		
8. 12.6.1 Technological Design a. Propose designs and choose between alternative solutions of a problem. b. Implement the selected solution. c. Evaluate the solution and its consequences. d. Communicate the problem, process, and solution.		

Concepts and Skills	Suggested Activities and Resources	Suggested Assessments
9. 12.8.2 Nature of Scientific Knowledge a. Demonstrate the use of empirical standards, logical arguments, and skepticism in science. b. Create scientific explanations consistent with experimental and observational evidence; make accurate predictions; strive to be logical; respect the rules of evidence; accept criticism; report methods and procedures; and make knowledge public. c. Understand that all scientific knowledge is, in principle, subject to change as new evidence becomes available.		

SECTION II **THE ATOM**

Concepts and Skills	Suggested Activities and Resources	Suggested Assessments
The Atom (15 days) **12.3.1 The Atom** a. Investigate and describe the structure of atoms, focusing on properties of subatomic particles. b. Investigate and explain the types of nuclear reactions. c. Investigate and describe the effect of electrical and nuclear forces which hold atoms together.		
12.8.3 Historical Contributors a. Investigate and describe the contributions of diverse cultures to scientific knowledge and technological inventions. b. Understand that changes in scientific knowledge evolve over time and almost always build on earlier knowledge. c. Understand that some advancements in science and technology have long-lasting effects on society.		
A. Structure of the Atom:		
1. Atomic models a. Thompson b. Rutherford c. Bohr		
2. Electrical and nuclear forces hold atoms together	1. Electrostatic activities (Vander Graff, comb, paper, etc.)	
3. Evidence supporting the existence of the electron a. Crooke (Cathode Rays) b. J.J. Thompson c. Properties of the electron	2. Cathode Ray Demonstrations/ Video Cathode ray tubes are used to demonstrate properties of electrons, including use of a Crooke's Tube.	Lab Write Up
4. Evidence supporting the nucleus of the atom a. Rutherford b. Properties of proton	3. Marble Lab Model This activity models Rutherford's famous gold-foil experiments and allows students to estimate the size of the nucleus of an "atom."	Lab Write Up
5. Relate subatomic particles to the atomic mass and atomic number a. isotopes b. ions c. decay (alpha, beta, gamma) d. Contributions of Marie Curie and Becquerel e. Neutron	4. Half Life Simulation Pennies and pizza boxes are used to collect data. In a closed pizza box the coins are tossed and all "heads" are removed and the process is repeated through 4-5 half-lives. 5. Transmutation Game *Interactions Course 3*, Glencoe, Activities Book Shows half-life and element it decays to. Playing cards and game boards are made by students are used to practice learning the new isotopes formed by alpha and beta decay.	

Concepts and Skills	Suggested Activities and Resources	Suggested Assessments
6. 12.5.3 Predict when rocks were formed by using known decay rates of radioactive isotopes in rocks.	6. Relative/Absolute Dating of Rocks (www.ucmp.berkeley,edu/fosrec/McKinney.html) This activity uses M&M's to determine half-lives. It has block diagrams to show relative ages of events and to introduce absolute dating. These are student centered activities. (Rated for grades 8-12)	Lab Write Up

SECTION III **MATTER**

Concepts and Skills	Suggested Activities and Resources	Suggested Assessments
Matter (30 days) **12.3.1 The Atom** a. Investigate and describe the structure of atoms, focusing on properties of subatomic particles. b. Investigate and explain the types of nuclear reactions. c. Investigate and describe the effect of electrical and nuclear forces which hold atoms together.		
A. 12.3.2 Structure and Properties of Matter • Investigate and understand that atoms interact with one another by transferring or sharing electron. • Investigate and explain the periodic table of elements in terms of repeating patterns of physical and chemical properties. • Investigate and describe how the structure of an atom determines the chemical properties of an element. • Investigate and describe how the interactions among the molecules of a compound determine its physical and chemical properties.		
1. Investigate and use changes in energy to explain the differences among states of matter. a. Phase changes 2. Electron configuration 3. Transferring and sharing of electrons a. Bonding i. Ionic ii. Covalent iii. Metallic 4. Periodic Table a. Investigate properties of some elements b. Examine patterns in the periodic table c. Valence electrons d. Properties of metals versus nonmetals	Predict the Properties of Element 114 Students use periodic data of known elements within the group to predict the molecular weight, density, and mass of element 114. Students then search the internet to compare their predictions to the most current information. Lab 7 Relationships Among Elements Laboratory Manual Science Interactions Course III, Glencoe Please, Set a Table! Science Discovery Activity *Science Interactions Course III, Glencoe* ***Ready to Use Chemistry Activities*** **Handwerker** **Center for Applied Research in Education** ISBN: 0-87628-438-1 Shows a periodic table, click on element to find history and properties **http://education.jlab.org/itselemental/** Interactive table of elements http://www.webelements.com/webelements/scholar/index.html	Lab Write Up Internet Research

Concepts and Skills	Suggested Activities and Resources	Suggested Assessments
B. 12.3.3 Understanding of Chemical Reactions • Investigate and describe common chemical reactions. (12.3.3) • Investigate and describe the change of energy as a result of chemical reactions. • Investigate and give examples of how systems tend to become more disorderly over time. (12.3.5) • Investigate and describe how electrons are involved in bond formation during chemical reactions. • Investigate and describe the bonding of carbon atoms in chains and rings to produce compounds essential to life. (12.3.2) • Investigate and describe the factors influencing the rates of chemical reactions including catalysts.		
1. Common chemical reactions a. Synthesis b. Decomposition c. Single replacement d. Double replacement e. Combustion 2. Balancing equations 3. Endothermic versus exothermic reactions a. Entropy 4. Catalysts, Temperature, Physical State, Surface Area Exposure, Concentration	Reaction Types Students will move from station to station to carry out each of the common types of chemical reactions. Students will write formulas for the reactions they observe. Activity 14: Sour Chemistry *Real World Math with the CBL System*, Brueningsen, etal, 1994, ISBM 1-886309-03-5 Lemon juice is neutralized with effervescent antacids. Data is collected using a pH probe and CBL system. Students analyze data using a math model.	Lab Summary Balancing Equations Work Sheets

SECTION IV **ENERGY**

Concepts and Skills	Suggested Activities and Resources	Suggested Assessments
Energy (25 days)		
A. Types of Energy • Kinetic (energy due to motion) • Potential (energy due to position) • Mechanical (kinetic + potential) • Thermal • Chemical • Electromagnetic • Nuclear		
B. 12.3.6 Interactions of Energy and Matter • Investigate and understand that all waves possess and transfer energy. • Investigate and illustrate how wavelength and frequency of waves are inversely related. • Investigate and understand that the energy of waves can be changed into other forms of energy can be transformed into energy, just as other forms of energy can be transformed into wave energy.		
1. Wave characteristics a. Wavelength b. Frequency c. Amplitude (crest and trough) 2. Wave types a. Transverse b. Longitudinal 3. Wave Activity	Activity Two: Sounds in Strings *Active Physics* (It's About Time, Inc.) Students use a string with varying lengths and masses to create numerous sound frequencies. Students can create a musical presentation based on their findings. (http://www.Its-About-Time.com) Absorb Physics for GCSE This site has some interactive demonstrations on waves. It requires students to use graphical data that students make calculations from to input solutions into the computer. This is a .com site that sells a more complete program. http://www.crocodile-clips.com./absorb/AP4/index.htm	Lab Write up
C. 12.3.6 Interactions of Energy and Matter • Investigate and understand that atoms or molecules can be identified by spectrum analysis. (Spectrum discussion).		
1. Spectrum analysis; electromagnetic spectrum (radio, micro, IR, visible, UV, x-ray, gamma ray) a. Sloan Digital Sky Survey Emission b. Spectra for stars are shown. Students can use the data available to classify specific types of stars based on spectral data c. http://cas.sdss.org		

Concepts and Skills	Suggested Activities and Resources	Suggested Assessments
D. 12.3.5 Conservation of Energy and Increase in Disorder • Understand that the total energy in the universe is constant and can never be destroyed. • Investigate and distinguish between kinetic energy and potential energy • Investigate and describe heat transfer in terms of conduction, convection, and radiation.		
1. Law of Conservation of Energy a. Mechanical b. Thermal (conduction, convection, radiation)		
E. 12.5.1 Understanding energy in the earth system • Investigate and distinguish between internal sources of energy (e.g., radioactive decay and gravitational energy) and external sources of energy (e.g., the sun), and explaining how both provide energy to the earth system. • Investigate and explain how the outward transfer of earth's internal heat drives convection in the mantle that propels the plates comprising the earth's surface. • Investigate and explain how global climate is determined by energy transfer from the sun and is influenced by dynamic processes (e.g., cloud formation and the earth's rotation) and static conditions (e.g., the position of mountain ranges and oceans).		
1. Energy in the earth system a. Core-mantle-crust structure (review) b. Thermal energy in Earth's interior drives the geosphere i. Evidence for interior heat 1) Volcanoes 2) Deep boreholes: deeper = hotter ii. Origin of heat in the interior 1) Residual from bombardment (mechanical energy, friction) 2) Radioactive decay (25% of heat) iii. Consequences of hot interior 1) Heat transfer through mantle to crust a) Plate tectonics: convection mantle moves the plates carrying oceans and continents b) Geological activity (volcanoes, earthquakes) at plate boundaries c. Solar energy (external) drives the atmosphere i. Radiant heat (infrared) 1) Absorption by land and water 2) Differential heating of surface leads to convection of the atmosphere a) Earth's wind (climate) belts b) Coriolis effect c) Influence of water bodies and land masses (rain shadow, differential absorption, wind deflection, etc.) d) Convection and cloud formation e) Cloud classification		

SECTION V **MOTION AND FORCES**

Concepts and Skills	Suggested Activities and Resources	Suggested Assessments
Motion and Forces (20 days) **12.3.4 Motions and Forces** a. Investigate and understand of force on the motion of objects. b. Investigate and understand gravity as an attractive force that each mass exerts on any other mass. c. Investigate and understand electrical force as a force that exists between any two charged objects. d. Investigate and describe an electric field a magnetic field, and the interaction between them.		
A. 12.8.3 Historical Contributors • Investigate and describe the contributions of diverse cultures to scientific knowledge and technological inventions. • Understand that changes in scientific knowledge evolve over time and almost always build on earlier knowledge. • Understand that some advancements in science and technology have long-lasting effects on society.		
1. Aristotle – Fire, Air, Earth, Water 2. Copernicus – Heliocentric Theories 3. Keppler – Planetary Motion 4. Galileo – Experimental Verification and Testing of Hypotheses 5. Newton – Mechanics 6. Einstein – Special and Relative Motion; Photoelectric Effect		
B. Newton's Law		
1. Law of inertia (1st) 2. Law of constant acceleration (2nd) 3. Action – reaction (3rd)	*TOPS Module 21 Motion* Marson, 1979 This module contains several activities testing uniform motion, tracking collisions, and Newton's second law. *Active Physics Sports* Eisenkraft, 1998, ISBN 1-891629-04-2 This text has a myriad of activities for students based on motion and sporting activities. *Physics with Computers* Gastineau, et.al., Vernier Software, 1998 ISBN 0-918731-99-2 This source uses interfacing systems to provide data collection and analysis activities to test numerous forms of motion. *Middle School Science with Computers* Volz and Sapatka, Vernier Software, 2000 ISBN 1-929075-08-1 This reference integrates interfacing systems and lab activities to test a variety of physics activities from the greenhouse effect to ocean floor mapping to various forms of motion.	

Concepts and Skills	Suggested Activities and Resources	Suggested Assessments
C. Gravity		
1. Force of attraction between any two objects 2. Distinction between weight and mass		
D. Electromagnetic Force		
1. Like and unlike charges (+ and -) 2. May be attractive or repulsive 3. Holds atoms together (electrons– and nucleus+) 4. 12.3.6—Understand that electromagnetic waves occur when a charged object accelerates. 5. Interactions between electrical and magnetic fields	Review electrostatic activities	

SECTION VI **ORIGIN OF THE UNIVERSE**

Concepts and Skills	Suggested Activities and Resources	Suggested Assessments
12.5.4 Origin of the Universe (8 days) a. Describe and analyze the Big Bang theory on the origin of the universe. b. Describe various types of galaxies including spherical, elliptical, and irregular c. Describe the life cycle of a star.		
A. Big Bang 1. Evidence for expanding universe a. red shift b. Hubble's Law **B. Galaxy Formation** 1. Classification of galaxy types **C. Birth and Death of Stars** 1. Hertzsprung-Russell diagram 2. Spectral analysis	1. Sloan Digital sky Survey (cas.sdss.org) By starting at the basic level several student/ teacher activities exist to challenge students, such as a scavenger hunt through the origin of galaxies and the universe. 2. Project Earth Science Astronomy Smith, NSTA Press, 2001, ISBN 0-87355-108-7 "Activity 6" Using vermiculite and water this model demonstrates the accretion theory when rotating interstellar clouds of gas and dust collapsed under its own gravity. 3. Celery seeds and a pan of water	Research paper Lab Report Class presentations

SECTION VII **CYCLES**

Concepts and Skills	Suggested Activities and Resources	Suggested Assessments
Cycles (16 days)		
A. 12.5.2 Understanding of Geochemical Cycles (5 days) • Investigate and diagram how elements and compounds on earth move among reservoirs in the solid earth, oceans, atmosphere, and organisms as part of geochemical cycles. (Water, Rock, Carbon, Nitrogen)		
1. Reinforce cycle concept a. Investigate and understand that atoms and molecules cycle among living and nonliving components of the biosphere. 2. Rock Cycle	Rock Around the Clock" *Project Earth Science Geology* Ford, 2001, "Activity 13: Students investigate the rock cycle using crayons. Shaved crayons are used to model chemical/mechanical weathering, as well as sedimentary rock formation	
B. 12.1.1 Develop an understanding of systems, order, and organization • Predict and evaluate how change within a system affects that system • Design solutions to problems identified within a system		
C. 12.7.6 Role of science and technology in local, national, and global challenges. (10 days) • Understand that knowledge of basic concepts about scientific and technological challenges should precede active debate. • Investigate and understand that social issues and challenges may affect advancements in science and technology. • Understand that science and technology are essential social enterprises that indicate what could happen, but not what should happen. • Social perspectives of global warming issue • Role of greenhouse gases (CO_2, CH_4, H_2O) 1. Evidence for increase and industrial influence 2. Evidence for global temperature increase 3. Examine and understand the societal, cultural, and personal beliefs that influence scientists. 4. Alternatives to fossil fuels: nuclear, renewable (solar, wind, hydro, biomass) • Carbon sources (combustion of fossil fuels, volcanoes, respiration 1. Short term (human time scale) • Carbon sinks (burial of biomass – coal, limestone, etc.) 1. Long-term (geological time scale)		

SECTION VIII **EARTH'S HISTORY**

Concepts and Skills	Suggested Activities and Resources	Suggested Assessments
Earth's History (17 days)		
12.5.3 Origin of the earth system a. Contrast the early earth with the planet we live on today. b. Investigate and estimate geologic time by observing rock sequences and using fossils to correlate the sequences at various locations. c. Investigate and relate how the interactions among the solid earth, oceans, atmosphere, and organisms affect the ongoing evolution of the earth.		
1. Explanations for plate movements (Pangaea and older continent-ocean configurations) a. Convection in the mantle b. Origin of the magnetic field c. Evidence for plate movement d. Plate tectonics theory	Video showing continent motions www.accessexcellence.com (General Science) *Project Earth Science* *Ford, 2001 "Activity 6: Convection"* (A convection cell in water is constructed by students. This model demonstrates how convection plays a role in plate tectonics.)	
2. Earth history and the rock record a. Geologic time scale b. Relative dating i. Superposition ii. Unconformities iii. Fossils c. Numerical dating i. Radiometric ii. Tree rings d. Interactions among earth systems in geologic time	**Earth & Astronomical Science Activities for Grades 5-12 ISBN: 0-87628-445-4** The Center for Applied Research in Education	